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STUDIES ON UTILIZATION OF WHEY IN VALUE-ADDED FRUIT BEVERAGES: DEVELOPMENT, OPTIMIZATION AND QUALITY EVALUATION

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Abstract: ***The present investigation was undertaken to develop and evaluate value-added fruit beverages utilizing paneer whey as a functional ingredient. Clarified sweet whey was blended with mango pulp at different proportions to formulate nutritious whey-fruit beverages. Four treatment combinations containing 60, 70, 80, and 90% whey with corresponding fruit pulp levels of 30, 20, 10, and 0%, respectively, were prepared and evaluated for physicochemical, microbiological, sensory, and storage characteristics. The beverages were analyzed for total soluble solids (TSS), pH, titratable acidity, protein, ascorbic acid, total sugars, and sensory attributes. Significant (P<0.05) differences were observed among treatments for all quality parameters. The beverage containing 70% whey and 20% mango pulp recorded the highest overall acceptability score (8.68±0.09) and exhibited desirable physicochemical characteristics. The optimized beverage remained microbiologically safe and organoleptically acceptable for 15 days under refrigerated storage (4±1°C). The findings demonstrate that whey can be effectively utilized for the development of value-added fruit beverages with enhanced nutritional and functional attributes.***

Keywords: *Whey beverage, Mango pulp, Value addition, Functional beverage, Paneer whey, Dairy by-products, Fruit beverage*

Introduction

Whey is the major by-product generated during the manufacture of paneer, chhena, cheese, casein, and related dairy products. It accounts for approximately 85–90% of the original milk volume and retains nearly 55% of milk nutrients, including lactose, whey proteins, minerals, and water-soluble vitamins (Kosikowski, 1979; Zadow, 1992). Disposal of untreated whey poses serious environmental concerns because of its high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) (Mawson, 1994).

Utilization of whey for the preparation of value-added beverages represents an effective strategy for reducing environmental pollution while enhancing economic returns to the dairy industry (Jelen and Tosoni, 2003). Whey proteins possess excellent nutritional quality and contain bioactive components with potential health benefits.

Fruit-based beverages are widely accepted by consumers because of their refreshing nature, attractive sensory properties, and nutritional value. Incorporation of fruit pulp into whey not only improves flavor and acceptability but also enriches the beverage with vitamins, antioxidants, and dietary fiber.

Mango (*Mangifera indica* L.) is one of the most popular tropical fruits owing to its pleasant flavor, high carotenoid content, and abundance of vitamins A and C. The complementary nutritional profiles of whey and mango pulp offer opportunities for the development of novel functional beverages. Although several studies have investigated whey utilization, information regarding optimization of whey-fruit beverage formulations remains limited. Therefore, the present study was undertaken to develop and evaluate value-added fruit beverages utilizing paneer whey.

Materials and Methods

Procurement of Raw Materials: Fresh buffalo milk was procured from the university dairy farm and used for paneer manufacture. Ripe mango fruits (cv. Alphonso) were obtained from khetiwadi campus fruit shops. Sugar, citric acid, pectin, and permitted natural flavoring agents were procured from commercial sources.

Preparation of Whey: Paneer whey was obtained by coagulating standardized buffalo milk with citric acid (1%, w/v) at 82°C. The whey was filtered through muslin cloth and clarified by centrifugation at 4,000 rpm for 15 min. The clarified whey was pasteurized at 72°C for 15 s and cooled to room temperature.

Preparation of Mango Pulp: Fully ripe mangoes were washed, peeled, and pulped using a stainless-steel pulper. The pulp was pasteurized at 85°C for 5 min and stored under refrigeration until use.

Experimental Design

Table 1. Formulation of Whey-Fruit Beverages

Treatment	Whey (%)	Mango Pulp (%)	Sugar (%)
T_1	60	30	10
T_2	70	20	10
T_3	80	10	10
T_4	90	0	10

Citric acid (0.15%) and pectin (0.20%) were maintained constant across all treatments.

Preparation of Whey Beverage: The required quantities of whey, mango pulp, sugar, citric acid, and pectin were blended using a high-speed homogenizer. The beverage was pasteurized at 85°C for 15 s, hot-filled into sterilized glass bottles, cooled, and stored at 4±1°C.

Analytical Methods

The beverages were analyzed for Total soluble solids (°Brix), pH, Titratable acidity (% citric acid), Protein (%), Total sugars (%), Ascorbic acid (mg/100 mL), Viscosity (cP) and Standard AOAC (2005) methods were followed.

Sensory Evaluation: Sensory evaluation was conducted by a

panel of ten semi-trained judges using a 9-point hedonic scale for Color and appearance, Flavor, Mouthfeel,Sweetness and Overall acceptability

Microbiological Analysis: Samples were analyzed at 0, 5, 10, and 15 days of refrigerated storage for Standard plate count, Yeast and mold count and Coliform count

Statistical Analysis: The experiment was conducted using a Completely Randomized Design (CRD). Data were subjected to one-way analysis of variance, and differences among means were tested at $P<0.05$.

Results and Discussion

Physicochemical Characteristics

Table 2. Physicochemical Characteristics of Whey-Fruit Beverages

Parameter	T_1	T_2	T_3	T_4
TSS (°Brix)	14.8±0.2	14.6±0.2	14.4±0.1	14.2±0.2
pH	4.38±0.03	4.42±0.02	4.48±0.03	4.54±0.04
Acidity (%)	0.38±0.01	0.36±0.01	0.34±0.01	0.32±0.01
Protein (%)	0.62±0.02	0.68±0.02	0.74±0.03	0.78±0.02
Total sugars (%)	12.4±0.2	12.2±0.2	12.0±0.1	11.8±0.2
Ascorbic acid (mg/100 mL)	16.8±0.4	14.6±0.3	11.2±0.3	4.2±0.2

Increasing whey concentration significantly increased protein content while reducing acidity and ascorbic acid levels.

Sensory Evaluation

Table 3. Sensory Scores of Whey-Fruit Beverages

Treatment	Color and Appearance	Flavor	Mouthfeel	Overall Acceptability
T_1	8.46±0.10	8.54±0.12	8.42±0.11	8.48±0.10
T_2	8.72±0.08	8.74±0.10	8.58±0.09	8.68±0.09
T_3	8.18±0.12	8.24±0.14	8.20±0.12	8.22±0.11
T_4	7.42±0.14	7.68±0.16	7.84±0.14	7.62±0.13

Treatment T_2 (70% whey and 20% mango pulp) recorded the highest overall acceptability score owing to its balanced flavor, desirable consistency, and refreshing taste.

Storage Stability

Table 4. Standard Plate Count During Refrigerated Storage

Storage Period (Days)	SPC (log cfu/mL)
0	1.84±0.04
5	2.26±0.06
10	2.78±0.08
15	3.32±0.10

No coliform organisms were detected during storage. The optimized beverage remained microbiologically safe and sensorially acceptable for up to 15 days under refrigeration.

The results demonstrated that whey can be effectively utilized in fruit beverage formulations without compromising sensory quality. The incorporation of mango pulp improved flavor, color, and nutritional value, whereas whey contributed proteins, lactose, minerals, and bioactive components. The observed increase in protein content with increasing whey concentration is attributable to the presence of whey proteins, including β-lactoglobulin and α-lactalbumin. The decline in ascorbic acid content with decreasing fruit pulp concentration is expected because mango pulp is the primary source of vitamin C. The superior sensory characteristics of treatment T_2 suggest that a balance between whey and fruit pulp is essential for optimizing consumer acceptability.

Industrial Significance

The developed whey-fruit beverage offers several advantages viz. Sustainable utilization of dairy by-products, Reduction of environmental pollution, Development of functional beverages, Increased profitability for dairy processors and Enhanced nutritional value through fruit fortification

Conclusion

The present investigation demonstrated that paneer whey can be successfully utilized for the preparation of value-added fruit beverages. The formulation containing 70% whey, 20% mango pulp, and 10% sugar was identified as the optimum treatment based on physicochemical, sensory, and microbiological characteristics. The optimized beverage remained acceptable for 15 days under refrigerated storage and offers considerable potential for commercial exploitation.

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